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Pattern of Integrated System of Smallholder Beef Cattle Central in Tegal Regency

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ABSTRACT

Purpose of this research is to focus on importance of knowing the activities of smallholder enterprise systems, types and trends in the patterns of integrated systems adopted, the impact of implementing integrated systems and the implications for sustainability of livestock systems. This research also emphasize the importance of opportunities in enhancing and increasing livestock productivity and increasing production in smallholder farms and developing the easiest formulation of strategies for sustainable livestock systems. A qualitative method using Soft System Methodology (SSM) from System Thinking was chosen to visualize the activities of smallholder enterprise systems and the pattern of integrated systems are presented descriptively. The next study method of quantitative is used to determine the impact of livestock productivity on each applied integrated systems presented comparatively. Soft System Methodology succeed to visualize smallholder enterprise systems at the level of individual and community level of farmer. Farmer's group activity influence the pattern of integrated systems that impacted on beef cattle's productivity. The ICLFS pattern promotes a way of optimally utilizing agroecosystems and it has potential and become candidate system that be able in enhancing and increasing productivity, increasing livestock production and farmer's income, and realize beef self-sufficiency.

Keywords: Enhancing and incerasing productivity, Pattern of integrated system, Self-sufficiency, System impact)

Introduction

There are various system used in running livestock enterprise, one of which is the integrated systems (Gayatri *et al*., 2016; Gil *et al*., 2015). Integrated systems is widely used by smallholder (Herrero *et al*., 2014; Riedel *et al*., 2014) by utilizing the potential of surrounding natural resources as the carrying capacity in the development of beef cattle enterprise (Vanlauwe *et al*., 2014). For example, forests and crops provide linkages interaction with cattle (Peyraud *et al*., 2014; Stefanski *et al*., 2015).

Several studies have concluded that the application of integrated systems has various benefits, which is; 1) crop residues into a source of feed, so that the needs of animal feed is sufficient (Mogensen *et al*., 2014); 2) livestock manure is used as fertilizer for crops (Vanlauwe *et al*., 2014); 3) utilization of local resources (Gayatri *et al*., 2016), 4) enhancing and increasing livestock productivity (Fust and Schlecht, 2018), 5) maintaining environmental sustainability and biodiversity (Kipling *et al*., 2016), and 6) promises a sustainable agricultural systems (Wu and Ma, 2015).

Smallholder beef cattle is the backbone of meat supply in Indonesia as a whole, both in terms of number of operations and production (Directorate General Livestock and Veterinary Services, 2017). Increased production and productivity are very important to be done by smallholder (Herrero *et al*., 2014). This is related to the amount of income earned for farmer household from the enterprise of beef cattle that is run (Setianto *et al*., 2014a). For household farmers, beef cattle are a main income for family survival, when household farmer are faced with difficult conditions, livestock can be sold to meet the needs (Setianto *et al*., 2014a).

The key to success in the development of beef cattle enterprise is the competence of farmers in utilizing natural resources optimally (Dossa *et al*., 2015). For example, the utilization of natural resources as the carrying capacity of livestock provides feed for livestock thus forming a pattern of integration between cattle enterprise with agriculture and forests (Peyraud *et al*., 2014; Stefanski *et al*., 2015). Pattern of integration is expected to improve the cattle enterprise that operated.

Objective of this paper is focused on the importance of knowing the activities of smallholder enterprise systems, the types and trends in the patterns of integrated systems adopted, the impact of implementing integrated systems on livestock productivity and the implications for sustainability of livestock systems. The paper also highlights the importance of opportunities in enhancing and increasing productivity and increasing production in smallholder farms and developing the easiest formulation of strategies for sustainable livestock systems.

Materials and Methods

Area description

The research was conducted on June 12th 2017 to January 13th 2017, in Subdistrict Margasari, Tegal Regency, Central Java Province. Subdistrict Margasari width is 9.88% (8684 ha) of total area of Tegal regency which is 87,879 ha and it has agroecosystem of food crop and forest (Statistic Service of Tegal Regency, 2017). The area of forest is used as an area for planting teak (*Tectona grandis*), mahogany (*Swietenia mahagoni*), sonokeling (*Dalbergia latifolia*) and sengon (*Albizia chinensis*) (Statistic Service of Tegal Regency, 2017). Food crops produced in Subdistrict Margasari consist of; rice, meize, and peanuts (Statistic Service of Tegal Regency, 2017).

Participant selection

Respondent is determined by the census method. The census method allows researchers to dig deep information on all population units and produce high-quality statistics (Neuman, 2014). A total of 13 groups of farmers (totally 188 farmers) who take shelter in Smallholder Beef Cattle Central (SBCC) or Sentra Peternakan Sapi Potong Rakyat (in *bahasa Indonesia*), called “Lembu Barokah”, made as respondents.

Data collection and analysis

This study refers to social research methods and how they are implemented using surveys (Neuman, 2014). A combination of qualitative and quantitative approaches is used as a technique for obtaining data and commonly called mixed methods research (Leppink, 2017; Taguchi, 2018) and it can be a design framework for getting the facts to get pragmatic solutions (Taguchi, 2018). Qualitative and quantitative approach provides a broad overview on the activities of integrated beef cattle enterprise systems (Gil *et al*., 2015).

Qualitative approach used to know activities of smallholder enterprise systems and types and trends in the patterns of integrated systems adopted which presented by descriptive. The instrument of thinking system chosen as a step to know smallholder enterprise systems and types and trends in the patterns of integrated systems is Soft System Methodology (SSM) (Setianto *et al*., 2014b). The next method of study is the quantitative approach used to determine the productivity of livestock in each system integration is presented in a comparative analysis. Flowchart in data collection and analysis can seen in Figure 1.

Smallholder enterprise systems and the patterns of integrated systems. The thing that needs to be done is to categorize the whole group of farmers based on the type of integrated system and livestock production system applied. There are three examples of integrated system, among others; 1) Integrated Crop-Livestock Systems (ICLS) ie integration of grain, grass and livestock production); 2) Integrated Livestock - Forestry Systems (ILFS) ie integration of tree, grass and cattle production; and 3) Integrated Crop – Livestock - Forestry Systems(ICLFS) ie integration of tree, grain, grass and cattle production (Gil *et al*., 2015).

The type of livestock production system generally consists of; 1) landless, 2) crop-based, 3) agro-pastoral, and 4) rangeland-based. The landless system consists of two categories, urban and peri-urban industrial, and rural landless livestock production system. The crop-based system consists of mixed farming (animal-annual crops and animal-perennial crops). Agro-pastoral is the integration of livestock with dryland farming. The rangeland-base system is found in dryland (Devendra, 2010).

The next step is to conduct semi-structured interviews on all respondents. The purpose of semi-structured interviews so that respondents are more open in expressing opinions and not limited by researchers. Three elements in the

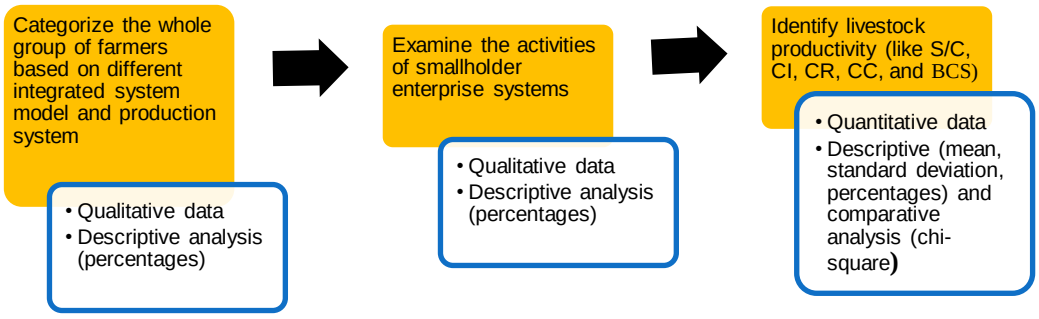

Figure 1. flowchart in data collection and analysis.

interview, among others; 1) identification of related actors (often interacting with farmer), 2) activities undertaken, and 3) related relationships therein (Setianto *et al*., 2014b). The system thinking method used in semi structured interview is SSM using two methods, namely rich picture and CATWOE analysis (Setianto *et al*., 2014b). Rich picture is a simple image that summarizes and explains all the circumstances in a system. While CATWOE analysis (Customers, Actors, Transformation, World-view, Owner, and Environment) helps find out how human activity contributes to system problems then produces system-root definitions (Fountas *et al*., 2015; Wang *et al*., 2015).

The next step of the workshop is conducted together with all actors as a step to pour the results of interview into rich picture. The workshop was held at a farmer's residence. The list of actors identified in the interview is then presented on poster size paper for discussion by the workshop participants. After that the discussion findings made the relationship in the form of diagrams between the actors related and their respective activities and then poured in the form of images by researchers as a draft rich picture. This draft is discussed again with all workshop participants to ensure that the picture is an actual situation (Setianto *et al*., 2014b).

Identify livestock productivity. Smallholder beef cattle in Indonesia usually keep two or three beef cattle (Sugiarto *et al*., 2018), one for cow-calf operation purposes or fattening (Rusdiana and Soeharsono, 2018; Setianto *et al*., 2014a). Indicators used in identifying productivity of beef cattle, among others; 1) reproduction efficiency performance for cow-calf operation; and 2) body condition score for fattening production performance.

The reproductive efficiency performance of cow-calf operation is measured from; 1) percent calf crop, by comparing total number of calves weaned by the number of cows exposed to breeding; 2) conception rates, namely the percentage of the number of cattle that become pregnant; 3) service per conception , ie the number of insemination performed on cattle to be pregnant ; and 4) calving interval, ie the distance of time to breed the cows until pregnant again (Eversole *et al*., 2009; Marx, 2008). While the fattening production performance is measured from the body condition score (BCS) of cows made fattening based on the existing fatty bodies using american methods of BCS scale 1-9 (Eversole *et al*., 2009; Marx, 2008).

This research uses triangulation method and data collection. Triangulation method combines the method between qualitative and quantitative approach. The objectives of triangulation to complement the weaknesses in each research approach (Rittichainuwat and Rattanaphinanchai, 2015). Furthermore, in the triangulation of data collection, the data obtained is a combination of qualitative data and quantitative data. Triangulation of data collection is used in calculating performance of beef cattle reproduction efficiency as measured by service per conception and calving interval. This is because farmers do not have records of livestock performance. The study was conducted with SBCC's Manger to get assurance that the findings were the correct data.

Statistical analysis

According Neuman (2014) that, qualitative data does not require statistical tests. The next research method using quantitative approach. Quantitative data are tested statistically on each productivity element. The data were analyzed using the IBM®-SPSS® software (Andreß, 2015) version 22. The description statistic used is measure of central tendency (Neuman, 2014) to know the average service per conception, calving interval, and body condition score on beef cattle in each farmer's group. Furthermore, in the three elements above is also used measure of dispersion that is useful to know the standard deviation (Neuman, 2014). The next productivity elements are the percent calf crop and the conception rates using the frequency distribution by category of data in percentage form (Neuman, 2014). To know the impact of implementing integrated systems on productivity, a statistical comparison of livestock productivity in each group was performed. The comparative statistical test method used is chi-square (Dossa *et al*., 2015; Gil *et al*., 2015).

Result and Discussion

Smallholder enterprise systems and the patterns of integrated systems

Figure 2a shows the translation workshop result of rich picture. Although the result of rich picture is very simple, but it can explain how the system works (Fountas *et al*., 2015; Wang *et al*., 2015). Rich picture describes the system at the household level of the farmer and the group level. A total of eight actors who have relationship with the activities of farmer groups, among others; farmer, farmer's households, peer farmer, SBCC, SBCC's manager, cattle traders, government, and universities. The role of each actor is shown in Table 1.

At the farmer's households level, all farmers in each group have no cops enterprise, because they do not have lands. Several farmers into farm labors (planting, plowing and weeding) as a second profession after rearing cattle. There are also farmers who work as elementary school teachers, sand diggers, motorcycle driver, and traders. However, the second profession does not interfere with the enterprise of beef cattle farming, because farmers implement the integrated system. The integrated systems allows farmers to more easily utilize local resources as the livestock carrying capacity (Vanlauwe *et al*., 2014) and the remaining time is used to seek additional income (Herrero *et al*., 2014).

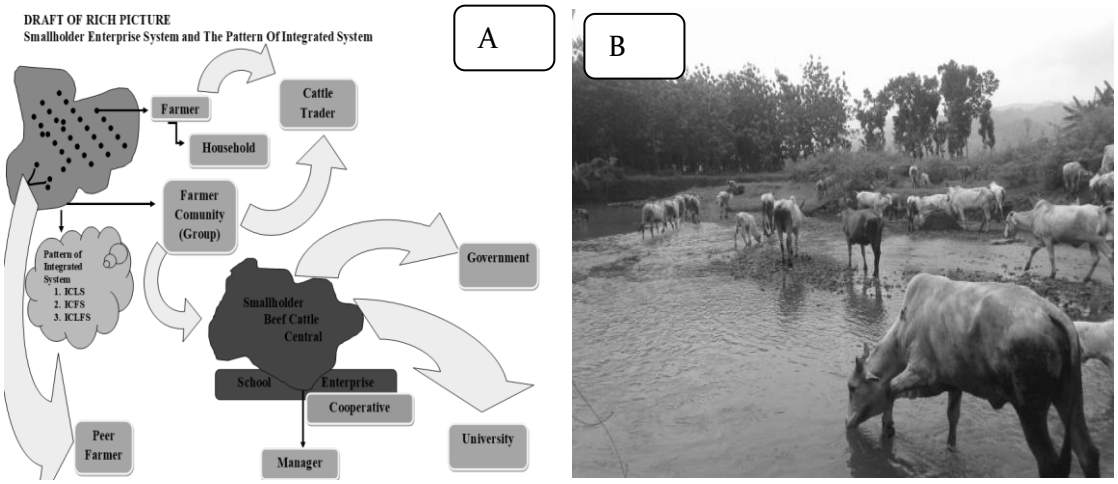

Figure 2. a) Rich picture of smallholder enterprise systems and the patterns of integrated systems; b) pasture of cows in forests.

Table 1. The role of actors in smallholder enterprise systems

Actor	Role
Farmer	Running a *smallholder* beef cattle enterprise
Household farmer	Provide manpower if needed for beef cattle enterprise
Peer farmers	Sources of information, knowledge and skills Sell and buy from/to peer farmers
SBCC	Facilitate farmers in enterprise development The Application of Smallholder Farming School
SBCC's manager	Manage enterprise, resource persons, supervisors, mediators, facilitators, and motivators
Cow traders	Provide cattle inventory at all times Buying and selling cows
Government	Extension services and Artificial Insemination
University	Provide technical/non-technical education/training to farmers Assistance to farmers

Furthermore, at the community level, farmers join with other farmers to form farmer groups. Factors that encourage individual farmers to form farmer groups are as a means to exchange information so that farmers can increase the knowledge, enterprise capacity and productivity of livestock maintained. Once the farmer group is running, then each group forms a systematic pattern of integration between cattle and crops or forests (Table 2). The majority of beef cattle farming in Tegal Regency is efforted on a smallholder with an average livestock ownership of 8.23±2.18 TLU. Tropical Livestock Unit (TLU) is a standard for categorizing cattle based on a 250 kg live weight. 1 TLU is equivalent to cattle = 0.80, sheep / goats = 0.10, pigs = 0.20, and poultry / rabbit = 0.01 (Dossa *et al*., 2015).

Number of farmers groups who implement ICLS as much as 5 groups (38.46%). The ILFS was applied in 4 groups (30.77%), while for the ICLFS implemented by 4 groups (30.77%). The majority of the groups apply livestock production systems based on crop-base and are integrated with annual-perennial crops . The pattern of integration can be observed in Table 2, among others; 1) ICLS pattern formed Beef Cattle-Rice-Maize-Peanuts-Grass; 2) ILFS pattern formed Beef Cattle-Grass-Tree; and 3) ICLFS pattern formed Beef Cattle-Rice-Maize-Peanut-Grass-Tree.

Various grasses can be found both in food crops and forests. The types of grass that can be found in the area of crops are; *Paspalum vaginatum, Digitaria ciliaris, Eleusine indica, Seteria sphacelate, and Brachiaria eruciformis*. On the other hand types of grass that can be found in forests, among others; *Angeratum conyzoides, Pennisetum purpureum, Crynodon dactylon, Seteria sphacelate, Brachiaria decumbens, Chrisopogon ariculatus, and Pennisetum purpupoides.*

The next level is based on the community level (group), rich pictures can identify that each group joined into the Smallholder Beef Cattle Central (SBCC) (Figure 2a). Each group join the SBCC voluntarily. The socialization of SBCC is done by the local government (related government service) with the universities and the participants of the socialization are the smallholder beef cattle individuals and groups) who will join the SBCC.

Smallholder Beef Cattle Central is the center of the growth of livestock commodities in a livestock area as a medium of development of animal husbandry and health (Directorate General Livestock and Veterinary Services, 2015). Smallholder Beef Cattle Central also serves as a vehicle for learning in obtaining or improving the competence of farmers. There is a smallholder farming school in which there are dissemination activities of innovation and

technology from various sources. The usual speakers are from universities and related livestock-service.

Universities and local governments also play a role in assisting the realization of groups in the SBCC have a legal entity. Table 1 also informs the role of universities that provides technical/non-technical education, training and assistance to farmers. The role of local government is to provide extension services and artificial insemination service, whereas SBCC's manager are collective enterprise manager who act as resource persons, supervisors, mediators, facilitators, or motivators for farmers.

Technically SBCC's manager supervise the production and productivity of beef cattle, help supply and market livestock and establish cooperation with other institutions. Some institutions who have established cooperation with SBCC ie university, local animal husbandry service dan banking. Manager also managed to establish cooperatives as a step to make farmers more prosperous. The cooperative is named smallholder cattle cooperatives and offering the society to invest.

Impact of integrated system on beef cattle productivity

The results showed that the model integrated system significantly (P>0.05) can affect the productivity of beef cattle (Table 3). ICLFS models are superior in S/C parameters (1.23±0.13), CI (12.21±0.42), and CR (87%), while ILFS is superior in CC productivity parameters (88%) and BCS (3.38±0.52). Unfortunately ICLS cannot increase cow productivity in each parameter observed.

Field facts show that the best beef cattle productivity in cow-calf operation and fattening is in the ICLFS system. The ICLFS system allows farmers to obtain variations of forage from crops and forests. Although crop residues depend on harvest time and season (Fust and Schlecht, 2018; Gil *et al*., 2015), but the fact that forage availability from forest has no effect on harvest time and season. Farmer can obtain forage from forest no matter when because availability of forage plenitude. Regarding the ease of getting forages for cattle, the ICLFS model allows farmers to be more optimal and easy to find forages than ILFS and ICLS.

The ICLFS system includes cows interacting with crops and forests (Gil *et al*., 2015). The pattern of integration formed inter alia Cow-Rice-Corn-Peanut-Variation of Grass-Tree. Pattern ICLFS excellent in forage availability which forest wearable any tme as feed resource and forests may provide a buffer against forage availability in the event of crop failure in food crops. Subdistrict Margasari is a sub-district with highest number of large ruminants and has agroecosystem in the form of crops (rice, meize, peanut) and forests (Statistic Service of Tegal Regency, 2017).

If Table 3 is observed more deeply, the Krajan Farmer Group seeks productivity of beef cattle well compared to other groups. The facts that the Krajan Farmer Group pasture the entire population of cattle to the forests (Figure 2b). The activity took place from 12:30 to 17:00 pm and it distinguishes it from other groups . Before departing for pasture of beef cattle, farmer look for forage on crops. In addition to pasturing, another group of farmers in obtaining forage is a cut-and-carry system. The system is done by cutting forage from crops or forest then bringing the feed to be given to beef cattle. Farmers looking for feed using motorcycles, tricycles, or bicycles.

Opportunities in enhancing and increasing livestock productivity

Based on Table 3, there is a significant impact on the application of ICLFS system integration pattern to beef productivity. The benefits of apply ICLFS are that crops and forest as an option within sustainability of feed supply for livestock so that beef cattle performance is optimal. Continuous feed availability allows to enhance and increase productivity and increase livestock production (Fust and Schlecht, 2018; Rusdiana and Soeharsono, 2018).

Table 2. Pattern of integrated system and beef cattle production system

Group name	Location	Type of production system	Integrated system	Pattern of integrated system
Lembu Jaya Nusantara	Dukuh Tengah Village	Crop-based	ICLS	Beef cattle-rice-maize-peanuts-grass
Suka Maju	Jatilaba Village	Crop-based	ICLS	Beef cattle-rice-maize-peanuts-grass
Rimba Jaya	Marga Ayu Village	Crop-based	ICLS	Beef cattle-rice-maize-peanuts-grass
Dadi Makmur	Marga Ayu Village	Crop-based	ICLS	Beef cattle-rice-maize-peanuts-grass
Bhakti Raharja	Jembayat Village	Crop-based	ICLS	Beef cattle-rice-maize-peanuts-grass
Sida Makmur	Prupuk Utara Village	Crop-based	ILFS	Beef cattle-grass- tree
Kebantingan	Dukuh Tengah Village	Crop-based	ILFS	Beef cattle-grass- tree
Wirajaya	Kalisalak Village	Crop-based	ILFS	Beef cattle-grass- tree
Lembah Sehat Sejahtera	Kalisalak Village	Crop-based	ILFS	Beef cattle-grass- tree
Krajan	Dukuh Tengah Village	Crop-based	ICLFS	Beef cattle-rice-maize-peanut-grass- tree
Banteng Jaya	Dukuh Tengah Village	Crop-based	ICLFS	Beef cattle-rice-maize-peanut-grass- tree
Banteng Mulya	Dukuh Tengah Village	Crop-based	ICLFS	Beef cattle-rice-maize-peanut-grass- tree
Sida Mulya	Pakulaut Village	Crop-based	ICLFS	Beef cattle-rice-maize-peanut-grass- tree

Table 3. Differences in beef productivity based on the applied integration system

Group name	Integrated system	Cow-calf operation				Fattening
		S / C	*C I (month)*	*CR (%)*	*CC (%)*	*BCS*
Lembu Jaya Nusantara	ICLS	1.32±0.16^{c}	12.75±0.45^{c}	79%	80%	3.42±0.51^{c}
Suka Maju		1.38±0.13^{i}	13.77±1.37^{h}	81%	77%	4.04±0.82^{f}
Rimba Jaya		1.35±0.10^{j}	13.71 ±1.53^{i}	82%	69%	3.82±0.81^{h}
Dadi Makmur		1.38±0.11^{m}	13.10±0.57^{j}	73%	74%	4.10±1.10^{i}
Bhakti Raharja		1.36±0.12k	13.50±0.71^{j}	72%	78%	3.90±0.74^{i}
Sida Makmur	ILFS	1.49±0.17^{l}	14.25±0.46^{k}	73%	75%	3.38±0.52^{j}
Kebantingan		1.39±0.14^{e}	13.92±1.31^{e}	83%	78%	4.25±1.36^{e}
Wirajaya		1.38±0.21^{f}	13.27±1.00^{f}	75%	88%	3.96±0.82^{f}
Lembu Sehat Sejahtera		1.41±0.13^{g}	14.13±1.20^{g}	72%	74%	4.13±1.02^{g}
Krajan	ICLFS	1.23±0.13^{a}	12.21±0.42^{a}	87%	83%	4.26±1.15^{a}
Banteng Jaya		1.26±0.14^{b}	12.43±0.65^{b}	82%	79%	3.79±0.70^{b}
Banteng Mulya		1.30±0.20^{d}	12.56±0.53^{d}	86%	72%	4.89±0.93^{d}
Sida Mulya		1.31±0.27^{h}	12.67±0.50^{d}	71%	75%	4.11±0.78^{d}

* 1) S/C (service per conception); 2) CI (calving interval); 3) CR (conception rates); 4) CC (calf crop); 5) BCS (body condition score)
* Superscript letters indicate statistical differences between group means (P<0.05).

The phenomenon that occurs in Indonesia is the high demand for beef, but the low availability of beef cattle makes the government to import from other countries. According to livestock statistics, by 2016 the Government of Indonesia has imported 116,761 tons of beef with a transaction value of 493 million USD (Directorate General Livestock and Veterinary Services, 2017). The import phenomenon of beef became an opportunity for farmers in increasing population and productivity (Sugiarto *et al*., 2018).

The issue of beef self-sufficiency has yet to be addressed. Beef self-sufficiency can be realized if the smallholder are able to enhance and increase the productivity and production of livestock. Application of ICLFS pattern to farmer group in SBCC answer how to improve the productivity and production of livestock. The ICLFS pattern promotes a way of optimally utilizing agroecosystems. Agroecosystem becomes the carrying capacity as a source of animal feed so that the performance of livestock become optimal (Fust and Schlecht, 2018; Gil *et al*., 2015; Herrero *et al*., 2014).

There are various reasons farmers do not implement ICLFS. It relates to; 1) low awareness of potential implementation of ICLFS; 2) the farmer's habit of utilizing one of the sectors on crops residues or forest; and 3) lack of information about the potential utilization of crops and forests. Integrated systems becomes the entry points as a strategy of beef cattle development in Subdistrict Margasari, Tegal regency.

The implications for sustainability of livestock systems and strategy of beef cattle development can be; 1) the implementation of government policy in favor of the development of systems based on integrated crop livestock forestry system; 2) the dissemination of potential benefits of the application of ICLFS; 3) communication between SBCC and the Forest Stakeholder facilitated by the government to establish cooperation in the development of variation of forage in the forest area; 4) technology transfer to farmers in order to improve the competence of farmers can be done in public livestock schools in SBCC by academicians and pythers from related government.

Conclusions

Smallholder enterprise systems consists of enterprise activities at the household level of farmers and enterprise activities at the farmer group level. Enterprise activities carried out at the level of farming households are beef cattle enterprise is run by a farmer assisted by family and aims to earn money as a livelihood. Further enterprise activities are those of farmers that run a beef cattle enterprise in groups and integrated with crops and forests. Significant integrated system models have an impact on beef productivity is Integrated-Crop-Livestock-Forestry-System (ICLFS). ICLFS promotes a way of utilizing the agroecosystems available for enhance and increase productivity and increase livestock production.

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